METAL MAKING LANCE ASSEMBLY

CROSS-REFERENCE TO RELATED APPLICATION

This application is a continuation-in-part of United States Patent Application Serial No. 10/167,711, entitled "METAL MAKING LANCE WITH DISPOSABLE SENSORS", filed June 11, 2002, which claims the benefit of United States Patent Provisional Application Serial No. 60/297,339, entitled "METAL MAKING LANCE WITH DISPOSABLE SENSORS", filed June 11, 2001.

FIELD OF THE INVENTION

The present invention relates in general to metal making lances and, more particularly, to metal making lances that are also capable of monitoring conditions within a metal making vessel.

BACKGROUND OF THE INVENTION

It has long been known to use probes, monitors or other sensor means to determine characteristics of metal that is being treated in a metal making vessel as well as the operating conditions of the vessel itself. The sensed data, which may include temperature, gas or other constituent concentration, or some other condition, are gathered and processed at or near real-time, typically by computer, and provide the vessel operator with important information about the progress or status of the metal making process occurring in the vessel. Metal making systems incorporating such technology often include means for automatically correcting the metal making process, e.g., by adding more or less of heat, gas and/or particulate matter to the vessel, if the

sensed data do not correspond with expected conditions at a particular phase of the process.

The sensors may be either intended for repeated use or they may be disposable and expended after a single use. If designed for repeated use, they may be used in association with metal making equipment such as refining lances that discharge combustible gases, inert gases and/or particulate matter into the metal making vessel during metal heating and refining processes. Under these circumstances, the sensors are incorporated into the lance structure itself whereby the lance structure serves as protection for the sensor. However, the lance structure must be specially designed and specifically adapted to accommodate the sensor which results in increased lance development and assembly time and cost. And, since the sensor is internal to the lance, if the sensor needs repair or replacement, the lance must be disassembled, thereby resulting in considerable lance downtime and maintenance costs. An example of a basic oxygen furnace (BOF) lance possessing an internal sensor assembly is shown in U.S. Patent No. 4,106,756.

A variety expendable or disposable sensors for metal making applications are marketed by Heraeus Electro-Nite of Houthalen, Belgium and others. As is known, expendable sensors are typically tethered to suitable hardware, instrumentation and calibration equipment by flexible communications cables. Such sensors, together with their associated hardware, instrumentation and calibration equipment offer a comprehensive control system for the online recording of temperatures and constituent elements such as carbon, oxygen, hydrogen, nitrogen, and aluminum in hot steel or other metal.

Expendable sensors may be categorized as sublance sensors and drop sensors. Sublance sensors are suspended by an auxiliary lance or sublance that is separate from the metal making lance. A dedicated sensing sublance adds considerable cost to the metal making operation. In addition, the presence of a separate sensing lance adds instrumentality to the metal making vessel that occupies valuable space that might be employed for other useful purposes. Further, a sublance mounted sensor is not an optimal means of reproducibly sensing characteristics in the metal making vessel occurring closely adjacent the metal making lance. Examples of such lances may be found in U.S. Patent Nos. 3,574,598; 3,869,369 and 4,272,989.

Drop sensors do not require a separate sublance for their placement in a metal making vessel and therefore consume less space in operation. However, they are difficult to position at targeted sites within a metal making vessel and cannot be reliably placed and maintained closely adjacent the metal making lance. Consequently, drop sensors, like sublance sensors, are less than desirable apparatus by which to monitor conditions close to the metal making lance. Examples of such sensors may be found in U.S. Patent Nos. 3,574,598; 5,275,488 and 5,610,346.

An advantage exists, therefore, for a system wherein disposable sensor means may be used in conjunction with a metal making lance in order to reliably sense conditions in a steel making vessel close to the metal making lance.

SUMMARY OF THE INVENTION

The present invention provides a metal making lance assembly wherein disposable sensors means may be used in conjunction with a metal making lance. More particularly, the assembly includes a sensor feed tube disposed interiorly or exteriorly of a metal making lance that is adapted to accommodate passage of at least one disposable sensor. The sensor means may be selected to detect one or more characteristics of a molten metal being treated and/or operating conditions of a metal treatment vessel, especially those in close proximity to the metal making lance.

Other details, objects and advantages of the present invention will become apparent as the following description of the presently preferred embodiments and presently preferred methods of practicing the invention proceeds.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will become more readily apparent from the following description of preferred embodiments shown, by way of example only, in the accompanying drawing wherein:

FIG. 1 is an elevational view of a first embodiment of a metal making lance assembly in accordance with the present invention;

FIG. 2 is an elevational view of a further embodiment of a metal making lance assembly in accordance with the present invention;

FIG. 3 is an enlarged view of the circled portion III of Fig. 2;

FIG. 4 is an elevational view of a further embodiment of a metal making lance assembly in accordance with the present invention;

FIG. 5 is an enlarged view of the circled portion V and a sensor means of Fig. 4;

FIG. 6 is an elevational view of a further embodiment of a metal making lance assembly in accordance with the present invention; and

FIG. 7 is an enlarged view of the circled portion VII and sensor means of Fig. 6.

DETAILED DESCRIPTION OF THE INVENTION

Referring to the drawings, wherein like references indicate like or similar elements throughout the several views, there is shown in FIG. 1 a metal making lance assembly according to the present invention identified generally by reference numeral 2. Lance assembly 2 includes a barrel 4 and a tip 6 fixedly attached to the barrel by welding, brazing or the like. As is known, tip 6 of lance assembly 2 discharges one or more gaseous and/or particulate materials through at least one nozzle at high velocities into a metal treatment vessel such as, for example, a furnace vessel (not shown) in order to melt, refine or otherwise treat metal, such as steel, aluminum, copper or alloy contained in the vessel. Tip 6 may discharge the gaseous and/or particulate materials at a distance from the metal being processed. Tip 6 may also be a so-called submergible (also known as immersible or submersible) tip adapted for insertion into a molten bath during metal processing.

All of the lance assemblies described herein function both as metal making lances and as sensing lances. In particular, they operate in a "metal making mode" wherein they function to heat and melt scrap metal, refine molten metal or otherwise actively treat metal and products in a metal treatment vessel. They are also capable of functioning in a "sensing mode" where they gather data about the conditions in the vessel or the metal and related products contained therein. The metal making and sensing modes may be performed concurrently or one may precede or follow the other.

Lance assembly 2 additionally comprises a sensor feed assembly 8. Assembly 8 includes a sensor feed tube 10 that is dimensioned, constructed and arranged to accommodate passage of disposable sensors means 12 (discussed below). Sensor feed tube 10 and its counterparts depicted in other embodiments of the present invention described later herein are separate from and isolated from fluid communication with the lance tip discharge nozzles. Sensor feed tube 10 may be affixed to the outer wall of barrel 4 by welding, brazing or the like. However, as described later herein, the sensor feed tube may alternatively be disposed interiorly of the lance barrel. In either case, the sensor feed tube is sized to accommodate passage of at least one disposable or expendable sensor means that is operable to detect one or more characteristics of the metal being treated and/or operating conditions within the metal treatment vessel. Among their advantages, expendable sensors are simple in design, relatively inexpensive and essentially maintenance free. In operation, they are consumed by the hostile environment of the metal making environment as they perform their dedicated sensing function. And, when exhausted, they are easily replaced by new sensors.

According to the embodiments of the invention shown in FIGS. 1-3, sensor means 12 preferably comprise a plurality of consumable sensors that are stackable end-to-end whereby they form a continuous electronic circuit that transmits signals corresponding to the data being sensed from adjacent the lance tip 6 to a data signal receiver 18 (FIG. 2). Data signal receiver 18 may include or may be electrically connected to suitable hardware, software, instrumentation and/or calibration equipment (not illustrated) whereby the sensor circuitry may be calibrated and the sensed conditions may be observed and/or recorded. By way of example, but not limitation, sensor means 12 may detect the temperature of the metal treatment vessel or the molten metal bath within the vessel and/or the concentration of one or more gases or other constituents, e.g., carbon, within the vessel or in the metal bath (not illustrated). For example, sensor means 12 may be selected so as to detect the temperature of the metal treatment vessel or, if lance tip 6 is submerged in a molten metal bath, the temperature of the bath. Alternatively, or in addition thereto, sensor means 12 may be selected so as to detect the presence and, preferably, the concentration of one or more chemical constituents in the metal bath, in slag material above the bath or in the vessel itself. Representative although not limitative examples of consumable sensor means 12 that would find beneficial use in the present invention in a steelmaking environment may include stackable, consumable and immersible sensors marketed by Heraeus Electro-Nite of Houthalen, Belgium or other manufacturers. Such sensors are preferably used in their typical manner in conjunction with hardware, instrumentation and calibration equipment marketed by Heraeus Electro-Nite or other manufacturers to provide a comprehensive control system for online recording of temperatures and/or constituent elements in the molten steel

bath, slag and/or steel making vessel. It will be understood that, consistent with the present invention, similar sensors and hardware, instrumentation and calibration equipment also marketed by Heraeus Electro-Nite or other manufacturers may be used in aluminum, copper or other metal and metal alloy treatment processes.

Optionally, sensor means 12 may include a sampler 14 for collecting a sample of the molten metal bath whereby compositional and other characteristics of the metal may be determined. Suitable sensors with samplers are available from Heraeus Electro-Nite and other manufacturers.

With sensor means 12 being constructed as a plurality of individual consumable sensors, sensor feed assembly 8 further preferably comprises sensor loading means 16 for serially depositing sensors 12 into the upper inlet end of sensor feed tube 10. A presently preferred sensor loading means 16 may be a linearly or rotatably movable mechanical, hydraulic, pneumatic, electrical, electromechanical, and semi- or fully-automated magazine loader capable of serially depositing sensors 12 into the inlet of sensor feed tube 10 as sensors are consumed at the lower or outlet end thereof. Sensor loading means 16 also preferably applies downward force to each newly-deposited sensor whereby a fresh sensor is indexed into operative position at the bottom of the lance assembly and a spent sensor is discharged in the manner described below.

Although not shown in FIG. 1, lance assembly 2 also includes means for firmly but yieldably gripping sensor means 12 whereby they are not inadvertently discharged from the lance during operation. A suitable sensor clamp means may be an annular spring-biased clip such as a split-ring or the like having an internal diameter smaller than the outer

diameter of the sensors. The sensor clamp means may be carried by the sensor feed tube 10 or, as shown by reference numeral 20 in FIG. 3, the lance tip 6. Alternative sensor clamp means may be one or more yieldable collet fingers or similar means carried on the inner surface of the sensor feed tube 10 or the lance tip 6. As the lowermost one of sensors 12 is consumed, a new sensor is placed atop the stack and pressed downwardly, thereby forcing all sensors therebelow downwardly as well. When the bottom sensor 12 passes the sensor clamp means, it falls into the metal bath and is replaced by the next sensor in the queue.

Referring to FIG. 2, there is shown another metal making lance assembly constructed according to the present invention, identified generally by reference numeral 2a. Lance 2a may, for example, be a fluid-cooled refining lance for use in a BOF or other metal treatment vessel. As is known, at the upper end of the lance assembly is a housing 22 comprising three or more housing sections. One of the sections includes a coolant inlet 24 and another includes a coolant outlet 26 for enabling circulation of coolant fluid such as water through the lance during operation. The housing also includes at least one additional section defining at least one additional inlet 28 that is adapted for connection to at least one source of oxygen-containing gas, inert gas and/or particulate material, which gas and/or particulate material is ultimately discharged by the lance from one or more nozzles 30 (FIG. 3) provided in tip 6a when the lance in its metal making mode.

Disposed atop the housing is a sensor feed tube inlet 32 for receiving sensor means 12a. The sensor means may be manually loaded into inlet 32 or they may be loaded from a sensor cartridge chamber or sensor loading means 16a similar

to sensor loading means 16 of FIG. 1. Sensor feed tube inlet 32 communicates with sensor feed tube 10a (FIG. 3) that resides interiorly of the lance. Sensor feed tube 10a extends the length of the lance and is connected by welding, brazing or the like to lance tip 6a. The lance tip, in turn, defines a sensor feed tube outlet 34 of substantially the same diameter as sensor feed tube 10a from which the sensor means extend during operation and are discharged when spent. Sensor feed tube 10a and those hereinafter described extend parallel to, and preferably are coaxial with, the central longitudinal axis "A" of the lance assembly. In this and other embodiments of the invention disclosed herein, the sensor feed tube inlet 32 is also preferably provided with a lateral inlet or coupling 36 for introducing a flow of pressurized inert purge gas such as nitrogen, argon, carbon dioxide or the like into the interior of the sensor feed tube. The purge gas is discharged from sensor feed tube outlet 34 to prevent slag ingestion that could cause clogging of the sensor feed tube.

FIGS. 4 and 5 depict a further embodiment of metal making lance assembly according to the invention. Certain reference numerals are provided in those figures and in FIGS. 6 and 7 for completeness of illustration but the structural components identified by those numerals are not described in detail since they correspond in structure and function to their counterparts in FIGS. 1-3. Only those elements in FIGS. 4-7 which materially depart in structure and/or function from previously discussed corresponding elements will be discussed in detail.

In FIGS. 4 and 5, sensor means 12b are preferably constructed as so-called drop sensors which may be stored in a sensor cartridge chamber or sensor loading means 16b

similar to sensor loading means 16 of FIG. 1. Unlike the stackable sensors 12 and 12a of FIGS. 1-3, only one drop sensor is received at a time within sensor feed tube 10b. It is dropped into sensor feed tube inlet 32 and falls through sensor feed tube 10b, sensor feed tube outlet 34 and into the metal bath (not illustrated). Sensor means 12b is tethered by electrical cable means 38 which transmit signals corresponding to sensed metal bath data to a data signal receiver 18 similar to that discussed in connection with FIG. 2. It is also possible that sensor means 12b and sensor means 12c of FIGS. 6 and 7, discussed below, could be wireless sensors which transmit their data to a wireless data signal receiver by radio frequency signals or the like.

In current practice, drop sensors are dropped adjacent a metal making lance. A disadvantage arising from dropping sensors adjacent the metal making lance is that it is difficult to reproducibly place the sensors in the same position with respect to the lance with each drop. Accordingly, as presently deployed, drop sensors do not provide information that is as reproducible and reliable as it could be. The assembly illustrated in FIGS. 4 and 5 overcomes this problem by creating a reproducible metal bath impact area for sensor means 16b that lies within the perimeter of the lance barrel 4b and preferably is coextensive with the central longitudinal axis A of the lance assembly. It is also possible that sensor means 12b could be dropped through an exteriorly mounted sensor feed tube similar to sensor feed tube 10 of FIG. 1. Although not as preferred as the assembly shown in FIGS. 4 and 5, such an arrangement would still be superior to the current practice of dropping sensors adjacent the metal making lance with no meaningful guidance mechanism.

FIGS. 6 and 7 depict a further embodiment of a metal making lance and sensor system according to the invention. While the sensor means 12c of these figures are also suspended by cable means 38, they are not dropped through the sensor feed tube 10c. Rather, they are inserted upwardly into the bottom of the sensor feed tube. More specifically, sensor means 12c comprises a sensor portion 40 and a connector portion 42. The connector portion 42 is a male electrical connector which may be compression fit, threaded or otherwise releasably inserted into the socket 44 of a female electrical connector 46 that is carried by and is in electrical communication with cable means 38.

After a metal treatment operation has been completed, the lance 2c is raised from a furnace vessel by unillustrated hoisting equipment. When sufficiently clear of the furnace vessel top or hood, the spent portion of sensor means 12c is preferably sawn or otherwise separated from the female connector 44 and discarded (desirably via a spent sensor discard chute 48 (FIG. 6). A new sensor means is then retrieved from a sensor loading means 16c and inserted into female connector 44 whereby it may await the next sensing operation. The aforementioned sensor removal and replacement process may be fully-manual, semi-automatic or fully-automatic.

From the foregoing, it will be appreciated that the present invention provides a combined metal making and sensing lance that obviates the need for separate, costly and space-consuming sensing sublances. It also successfully deploys economical and essentially maintenance-free disposable sensors in a uniform and reproducible way that cannot be duplicated by current unguided sensor dropping techniques.

Although the invention has been described in detail for the purpose of illustration, it is to be understood that such detail is solely for that purpose and that variations can be made therein by those skilled in the art without departing from the spirit and scope of the invention as claimed herein.